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Serie Havundersøkelser

Report on Norwegian Fishery and Marine Investigations
Vol. IX. No. 6

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The Variation in Growth of young Codfishes from the Norwegian Skager Rack Coast

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Cod Scales as Indicator of Local Stocks

By

Alf Dannevig

The Flødevig Sea-fish Hatchery

1949

A.s John Griegs Boktrykkeri, Bergen

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The Variation in Growth of young Codfishes from the Norwegian Skager Rack Coast

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By **Alf Dannevig.**
The Flødevig Sea-fish Hatchery.

In a paper on the age and growth of the cod (A. Dannevig 1933) I have demonstrated that the growth of the grown up cod differed from one fjord to another and from the fjords to the »skjærgård«.

In order to approach this problem more closely, it is of importance to study the length increment from the earliest stages.

Since 1903 we have made a great number of hauls with a fine-meshed seine in order to ascertain the number of cod and other gadidae half a year of age in the littoral region. Certain localities along the Skager Rack coast have been examined every year, and as far as possible at the same date. The fish is mostly measured alive and put back to sea again. In this way the individual measurements are not very accurate, but their means will suffice for the purpose in hand. When the measurements are put down in graphs the 0-group will generally materialize as a well defined size-group, separated from the older year classes. The average size of the 0-group is then ascertained. During the summer this method works quite well, but in the autum the 0 and I group may overlap. In the later years the age of the individuals being at the limit have been ascertained by the otolith method.

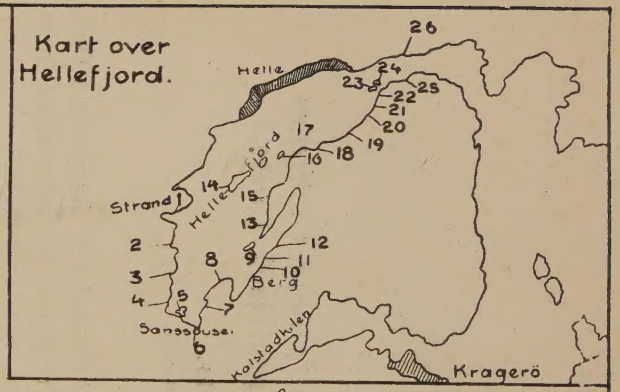
Some fjords have been examined in detail, and we have here the opportunity to study the length of the fish from the inner to the outer part. In most cases, however, we must confine ourselves to study the length of the fish in different fjords.

During the years 1903 to 1905 the Søndeledfjord was examined by K. Dahl and G. M. Dannevig (Bergen 1906). The Søndeledfjord, near Risør, is divided by an island into two parts along the longitudinal axis of the fjord (Fig. 1). The Nordfjord is relatively deep and open to the bay of Risør, but outside there is shallow water and many islands. The Sørfjord communicates with the Nordfjord at its inner part. Towards the bay of Risør, the Sørfjord communicates by a quite narrow

Fig. 1.

Kart over Söndeledfj. og Risör skjærgaard.

– 1 (Tal.) = lokalitet undersögt med Dannevigs vad.



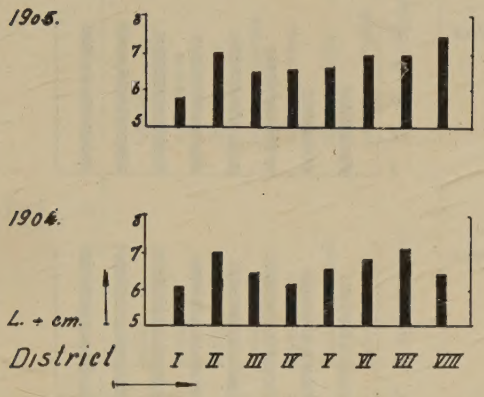
sound about 10 metres broad and 2 metres deep. In the Sørfjord there are some shallows, alternating with relatively deep basins.

The Nordfjord is well ventilated. The Sørfjord is less so, and in the eastern and middle part the deeper layers are contaminated by hydrogen sulphide. In the inner part of the Sørfjord we have some brooks coming down. And at Søndeled a small river enters the Nordfjord.

Fig. 2.

Søndeledfjord summer 1904 - 1905.

Cod. Average length of 0-group.



In order to simplify the examination, the Søndeledfjord was divided into 8 compartments as shown in figure 1. The waters were examined for the first time in September 1903. In figure 2 the results are given for the investigations in July/August in the years 1904 and 1905. From the figure it is evident that the average size of the cod differs from one district to another. The values are parallel for the two years, except for district VIII, the »skjærgård«, where the cod is relatively large in 1905. The number caught that year, however, is low. (Table I). For 1904 the differences between the means for each district are generally larger than $3 \cdot \varepsilon$ (d), in 1905 the number being less, this is not the case. But according to the parallelity between the two years we must expect the values to be valid for 1905 as well.[1])

In District II the codling is relatively large in both years. For 1904 the difference between district I and II amounts to 0.91 cm, $= 7{,}1 \cdot \varepsilon$ (d). It is not probable that this difference in the size of the codling of those two districts, but a few kilometres apart, is due to a difference in time

[1]) The means have been statistically examined by cand.oecon. Knud Jens Christensen.

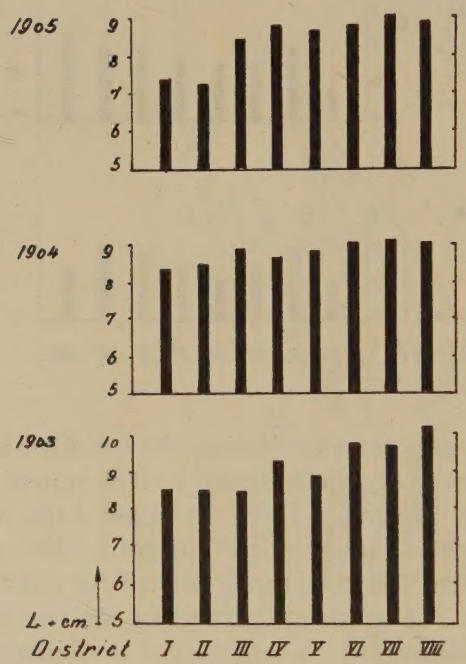
of hatching — or to hereditary qualities. The difference in length must be ascribed to some local effect, beneficial in district II or inconvenient in district I.

The size of the codling is relatively great in districts VI, VII & VIII, that is in the part of the fjord where the watermasses are well aereated.

Fig. 3

Søndeledfjord autumn 1903-1905.

Cod. Average length of 0-group.



Turning now to the investigations in the autumn (figure 3), the material is scanty in 1903, but the average length of the fish in each district corresponds with the values for 1904 & 1905. Now the codlings from district I & II are of equal size and they are smaller than in the other districts.

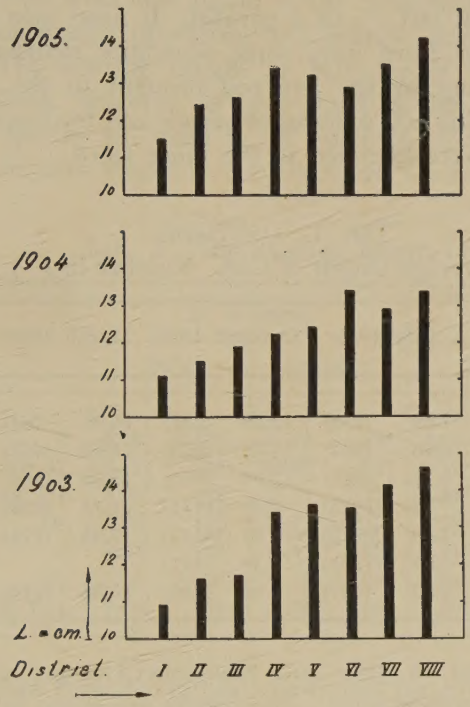
If we neglect the influence of the narrow channel in the eastern part of the Sørfjord, as we certainly can, we may say that during early autumn the size of the codling increases from the inner to the outer part of the fjord. It ought to be remembered, however, that the hauls in the inner fjord, district I & II, are performed approximately 8 days earlier

than in the outer fjord. This space of time equals an approximate length increment of 3 mm which of course must be taken into consideration. The difference in length amounts, however, to at least three times that value.

During the same investigations a considerable number of whiting of the 0-group was collected, — especially in the September hauls. In

Fig. 4.

Söndeledfjord autumn 1903-1905.
Whiting. Average length of 0-group.



July—August the number is too low to give reliable means as to the size in each district. Figure 4 illustrates the results attained in the autumn. It is evident that also in the case of the whiting, the mean size of the 0-group is smallest in the inner fjord and augments outwards. The length increment, due to the space of time between the investigations in the inner and outer fjord, amounts to approximately 5 mm. The actual difference in length is about 20 to 30 mm.

In the Oslofjord the occurrence of young fish in the littoral zone was ascertained during the years 1936 to 1939 (Løversen 1946). As to the cod, the material is too scanty to give good averages as to the

length of the fish in each district in all years except in 1938. In this fjord the occurrence and size of the larvae and quite young ones were also investigated in the spring (Dannevig 1945). Table 6 of that paper gives the size of the pelagic cod in the first week of May 1938. In the inner part of the fjord the larvae have not reached a length of 10 mm. In the outer part of the fjord the larvae are more than 10 mm. By the investigations of Trygve Braarud and Adam Bursa, Oslo 1939 and Kristian Fredrik Wiborg, Oslo 1940 it is demonstrated that the spring development of the phyto- and zooplancton normally occurs later in the inner than in the outer fjord. The difference in size of the cod fry may be a response to that fact — or a parallel. It must also be mentioned that we in the inner fjord have some »foreign« elements. We must expect some spawning by the live cod brought to the Oslo market. And in the same spring 100 millions of pelagic cod fry from the Flødevig Sea-fish Hatchery were liberated in the inner fjord.

Tab. 1. *Oslofjord.*
The average length of Cod. Number in ( ).

	July 1938		October 1938		March 1939		July 1939	
Bonnefjord I.	7.69	(255)	13.29	(287)	16.06	(63)	13.49	(57)
Bygdøy—Håkavik II.	8.16	(903)	11.98	(683)	14.02	(467)	15.75	(115)
Nærsnæs—Håøya III.	9.18	(526)	12.03	(470)	13.63	(196)	14.92	(37)
Drøbak IV.	7.72	(1985)	9.88	(1731)	11.75	(238)	13.48	(44)
Holmestrand V.	7.48	(6920)	8.88	(3557)	15.58	(471)	17.90	(141)
Hvaler VI.	6.64	(1288)	9.39	(411)			19.81	(48)
Vrengen—Tjømø VII.	8.02	(447)	8.98	(758)	10.96	(110)	17.73	(26)

During the first of July and September/October the fjord was fished with a smallmeshed seine. The results are given for each district in table I. District I is the inner-most part. In July the divergences between the means are not very great — the smallest individuals are caught at Hvaler, District VI, and the largest in the middle of the fjord, District III.

In October things have altered, the young cod is much larger in the inner fjord — in the outer part the length increment has been relatively very slight.

The cod from the inner fjord kept its leadership till March 1939. But from that time, at an age of one year, it drops back and the cod from the outer fjord takes the lead. As pointed out by Løversen (loc.cit.) the small size of the 1 to 2 year old fish in the inner fjord may to some

degree be ascribed to the intense fishing here. The bigger specimens of the yearclass are now large enough to be retained by different gears. The results attained here are, however, in conformity with the results attained by scale measurements and determination of age of the cod in the Oslofjord (A. Dannevig 1949). The cod of the inner fjord grows quickly during the first year — but later the growth is slow. See also Ruud (1939).

As to the 0-group it is interesting to note that the length of the cod in the Oslofjord during autumn is highest in the inner fjord in direct contract to what was found in the Søndeledfjord.

The measurements of whiting and pollack caught in 1938 are given in table 2. The whiting caught in July are of approximately equal size. The pollack, however, is very small in the outer fjord. In the autumn both species are small in the outer part. As to the growth of these species in later stages in the Oslofjord we know nothing.

Tab. 2. The average length of:

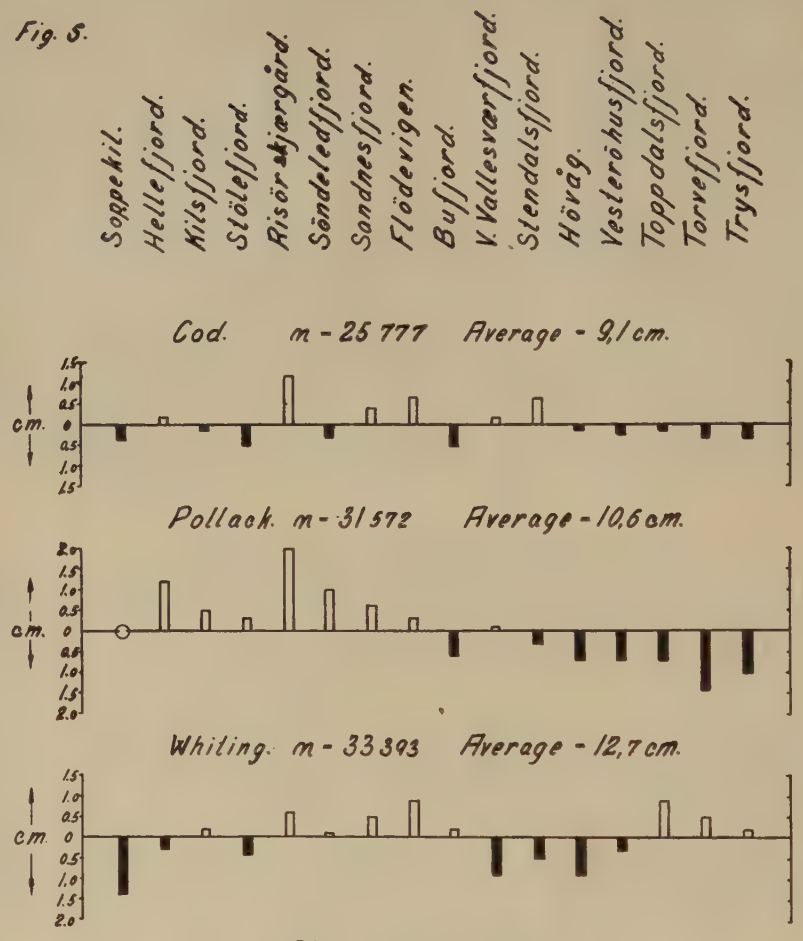
1938	A. Whiting				B. Pollack			
	July		October		July		October	
Bonnefjord I.	8.08	(1405)	17.15	(26)	5.62	(97)	14.97	(65)
Bygdøy—Håkavik II.	8.11	(255)	13.35	(94)	6.12	(263)	14.68	(192)
Nærsnæs—Håøya III.	8.50	(38)	15.81	(27)	6.31	(244)	14.51	(91)
Drøbak IV.	8.55	(40)	13.75	(319)	6.58	(152)	12.75	(232)
Holmestrand V.	8.64	(133)	13.14	(157)	6.41	(22)	11.38	(109)
Hvaler VI.	8.50	(166)	11.53	(104)	2.93	(514)	11.01	(128)
Vrengen—Tjømø VII.	7.90	(98)	11.64	(99)	3.89	(110)	11.47	(68)

It is evident that the natural conditions for growth of the 0-group codfishes must be very good in the inner Oslofjord. It is reasonable to assume that the cause is the effluents of the the sewages of Oslo, bringing great quantities of nourishment for the phytoplancton, from which a rich zooplancton may arise.

Fig. 5 illustrates the average length of the cod, pollack and whiting in different fjords on the Norwegian Skager Rack coast — from East to West. There is no special trend except for the pollack, — the 0-group is larger in the Eastern than in the Western part. The pollack in our waters is a southerly form, it may thrive better in the Eastern fjords where the temperature is higher during summer.

Taking all species into consideration three localities give relatively high values. The Skjærgård near Risør, the Sandnesfjord and the

Fig. 5.



Skager Rack Coast.
Littoral region 1917 - 1946.
Average length of the 0-group in autumn given as deviation from the mean for all fjords.

waters near Flødevigen — all open and well ventilated waters. The Soppekil, Høvåg and Vesterøhusfjord give small values. Those are narrow waters, badly ventilated.

We may summarize the results of measurements of the 0-group half a year of age in the following way.

The Søndeledfjord:

The length of the 0-group of cod & whiting is augmenting from the inner to the outer fjord. This is in conformity with the grown up cod — the cod from the Søndeledfjord is by far smaller than the cod at the same age from the coast (A. Dannevig 1933).

The Skager Rack coast:

The length of the 0-group of the cod & whiting is relatively small in the poorly ventilated fjords. And relatively great in open waters. The 0-group of the pollack is greatest in the Eastern district.

The Oslofjord:

In the autumn the length of 0-group of the cod, whiting and pollack in the inner fjord is very great and surpasses that of the 0-group in the outer fjord. At the age of one year the increment in length of the cod in the inner fjord seems to decrease. The examination of the scales of the yearclass 1938, referred in another paper, points in the same direction. The scales of the cod from the inner fjord have a relatively great central zone with broad sclerites indicating a quick growth, which in the second year is followed by relatively narrow sclerites. This is verified by the examinations of Ruud (1939): the grown up cod in the inner fjord is — at the same age — much smaller than in the outer fjord.

The inner Oslofjord thus divergates from the other areas investigated in having good conditions of growth for the quite young codfishes. As previously mentioned this may be ascribed to the fertilizing effect of the sewages from Oslo. This seems, however, to have no beneficial effect to the older fish. Or the beneficial effect may be counteracted by other unfavourable conditions.

The inner Oslofjord excepted, it seems that the low growth rate earlier ascertained for the older cod in the inner fjords is remarkable already when the fish is about half a year of age.

It is thus to be assumed that the young cod in these waters must be very stationary.

Table I. *Søndeledfjord.*
Number of cod and whiting of the 0-group.

District	Sept. 1903	July 1904	Sept. 1904	July 1905	Sept. 1905
			A. Cod.		
I.	17	481	131	42	31
II.	23	120	100	14	34
III.	21	220	142	34	74
IV.	86	863	323	127	94
V.	84	489	242	305	303
VI.	24	378	148	102	80
VII.	148	796	421	486	473
VIII.	24	210	102	44	130
			B. Whiting.		
I.	93		214		53
II.	71		148		74
III.	46		82		67
IV.	144		364		96
V.	184		247		87
VI.	50		62		37
VII.	624		155		487
VIII.	99		34		94

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Cod Scales as Indicator of Local Stocks.

By **Alf Dannevig.**
The Flødevig Sea-fish Hatchery.

In two earlier papers on the growth of the cod I have dealt with the cod scale as an indicator of growth (Dannevig (1925) and (1933)).

The first investigations were based upon material from cod kept in captivity at the Flødevig Sea-fish Hatchery, the latter on material from the Norwegian Skagerak Coast. The results obtained with the cod kept in captivity indicated that the formation of small sclerites in the scales normally took place in late summer or early autumn. For individuals with slow growth the formation of small sclerites might be prolonged into winter. The formation of maximum sclerites generally took place during winter, and as the measurements revealed great length increment in that season, the theory of a correspondence between rapid growth and large sclerites, slow growth and small sclerites, was verified.

The material from the sea indicated that in the 0-group small sclerites were formed in August. The minimum sclerites were soon followed by large sclerites corresponding to a quick growth of the fish. As to the older fish large sclerites were normally formed between November and July. Small sclerites were, however, found at the margin in all months of the year, but it is evident that August is the principal season for the formation of narrow zones. In one case 100 % of the fish examined had narrow sclerites at the margin in early autumn. The formation of small sclerites at other seasons may lead to supernumerary zones — and as we were unable to distinguish those, we had to drop the scales as an indicator of age, especially as the otoliths proved to be very reliable and convenient for that purpose.

When dealing with the cod scales, we found that their character might differ from one district to another. When in 1938 we succeeded in getting an ample sample of that yearclass, we tried to attack that problem more closely by way of sclerite measurements. Material was

collected from different localities from summer 1938 till the war started in 1939/1940.

The method used is described in the paper mentioned above (Dannevig 1925). The sclerites are measured as shown in Fig. 1 and the results entered in graphs as ordinates. In the abscissa the sum of

Fig. 1. Scale of cod 9,8 cm. October 11th, 1919.
Illustrates the measurement of the sclerites.

sclerites along the distal »radius« of the scale is reduced to the length of the fish. According to the theory that the scale growth is approximately proportional to the growth of the fish, the ordinates of any sclerite curve should correspond to the length of the fish when the sclerite was formed. The high ordinate near origo represents the »radius« of the central plate of the scale.

In Figures 2 a, b, and c such curves are given for 10 mediumsized codling about 1½ year of age. The curves from Flødevigen and Holme-

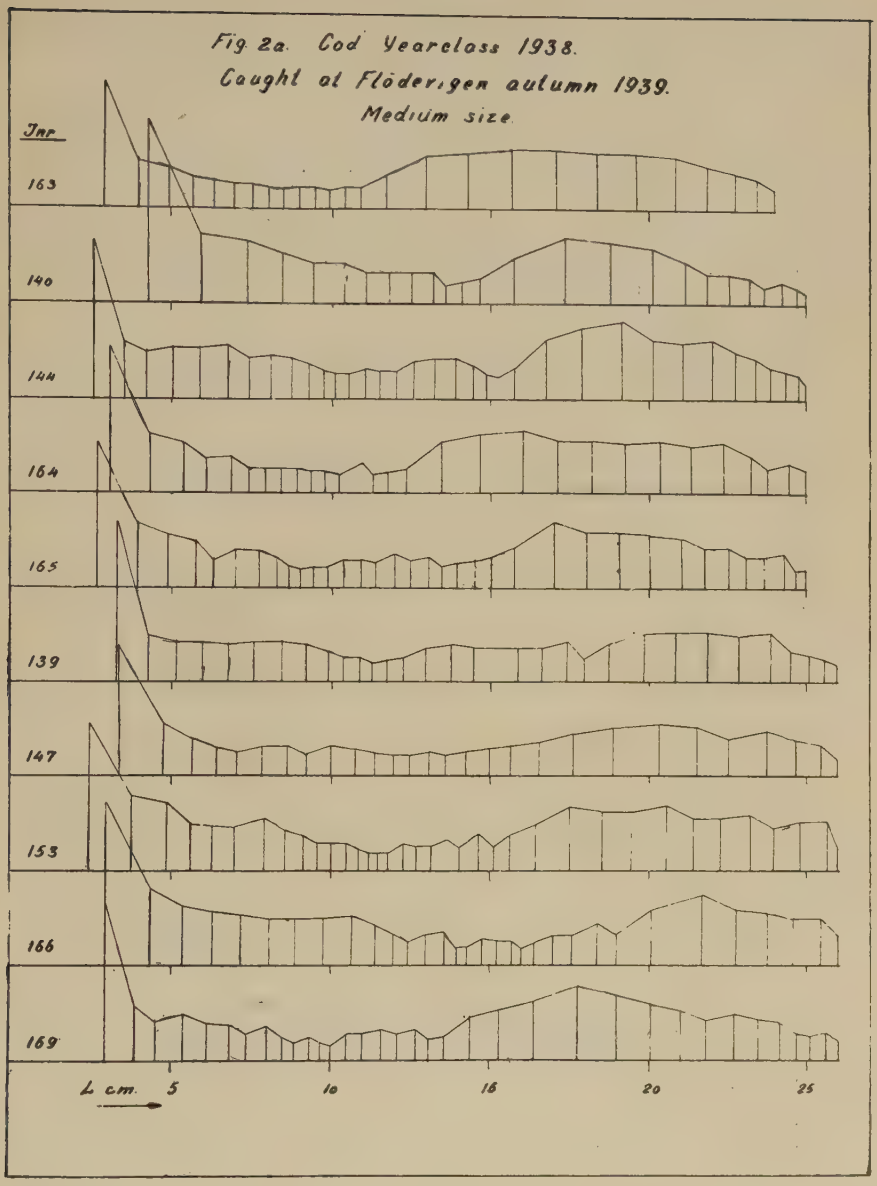


Fig. 2a. Cod Yearclass 1938.
Caught at Flöderigen autumn 1939.
Medium size.
Jnr.
163
140
144
164
165
139
147
153
166
169
L cm. 5
10
15
20
25

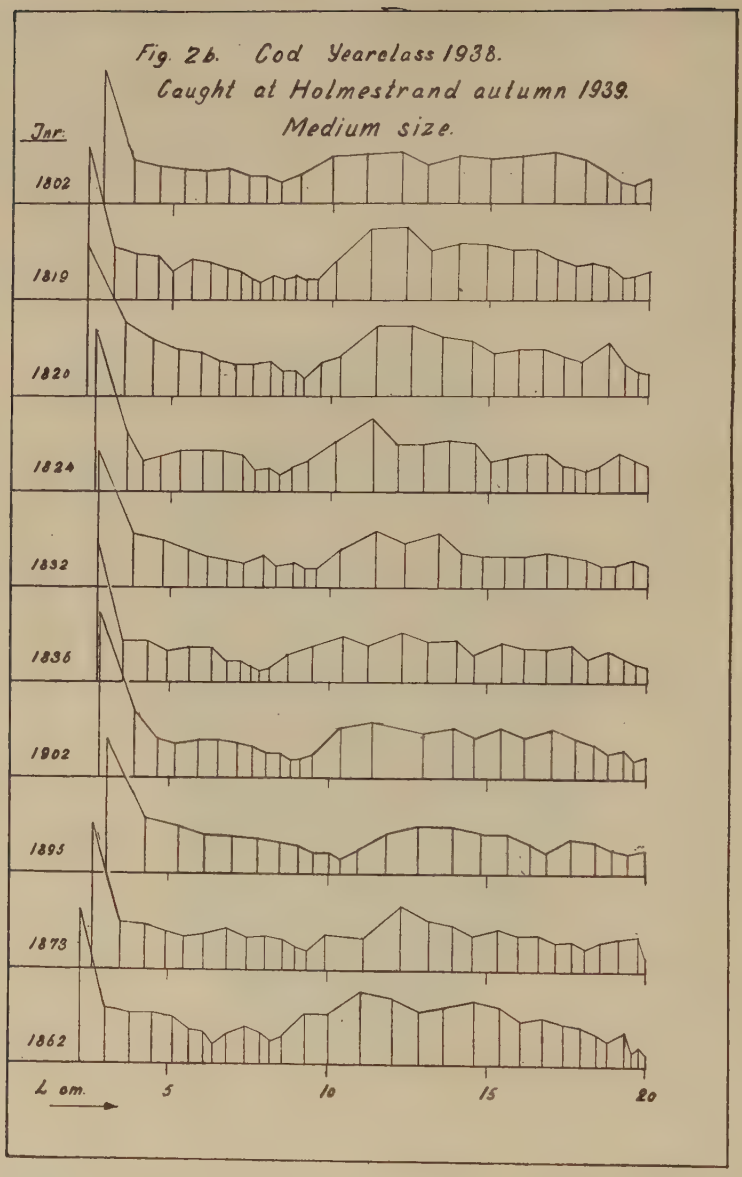


Fig. 26. Cod Yearclass 1938.
Caught at Holmestrand autumn 1939.
Medium size.
Jnr:
1802
1819
1820
1824
1832
1836
1902
1895
1873
1862
L cm.
5
10
15
20

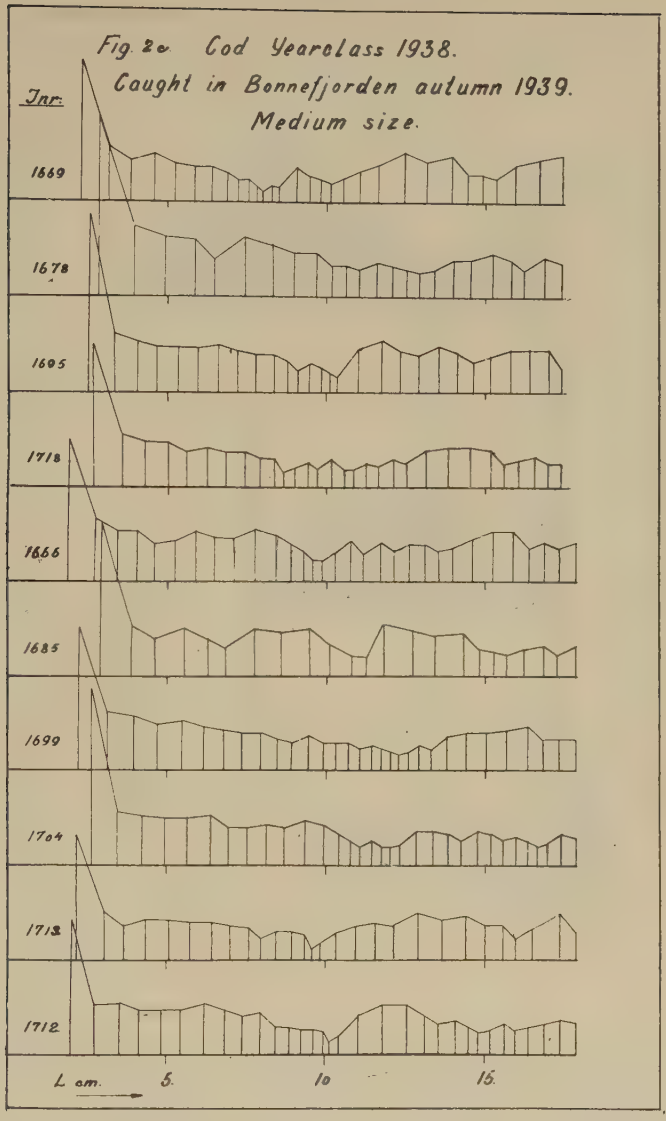


Fig. 2a Cod Yearclass 1938.
Caught in Bonnefjorden autumn 1939.
Medium size.
Jnr:
1669
1678
1695
1718
1656
1685
1699
1704
1713
1712
L cm.
5.
10
15.

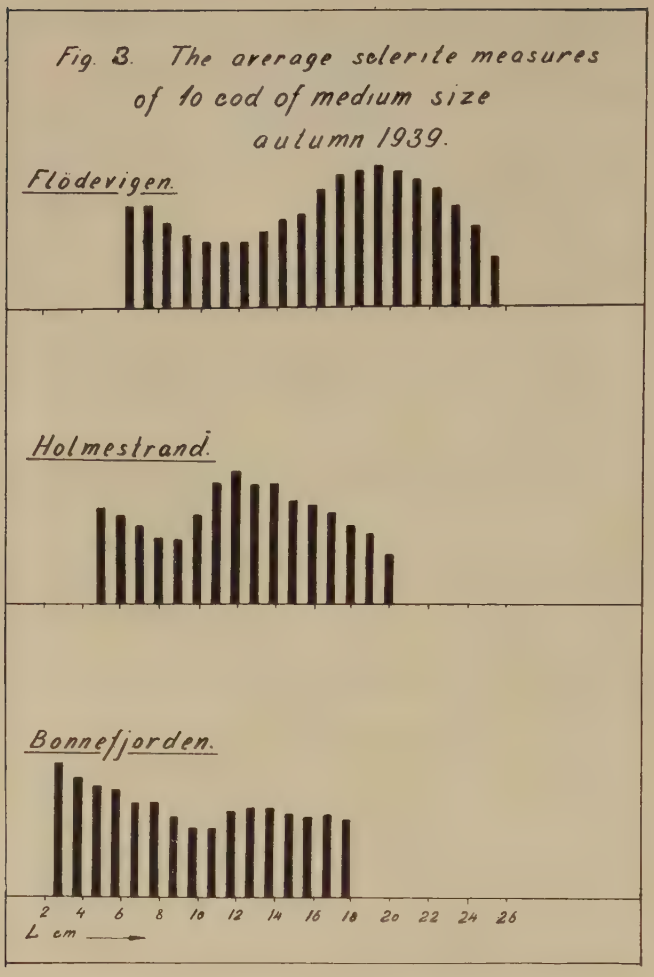
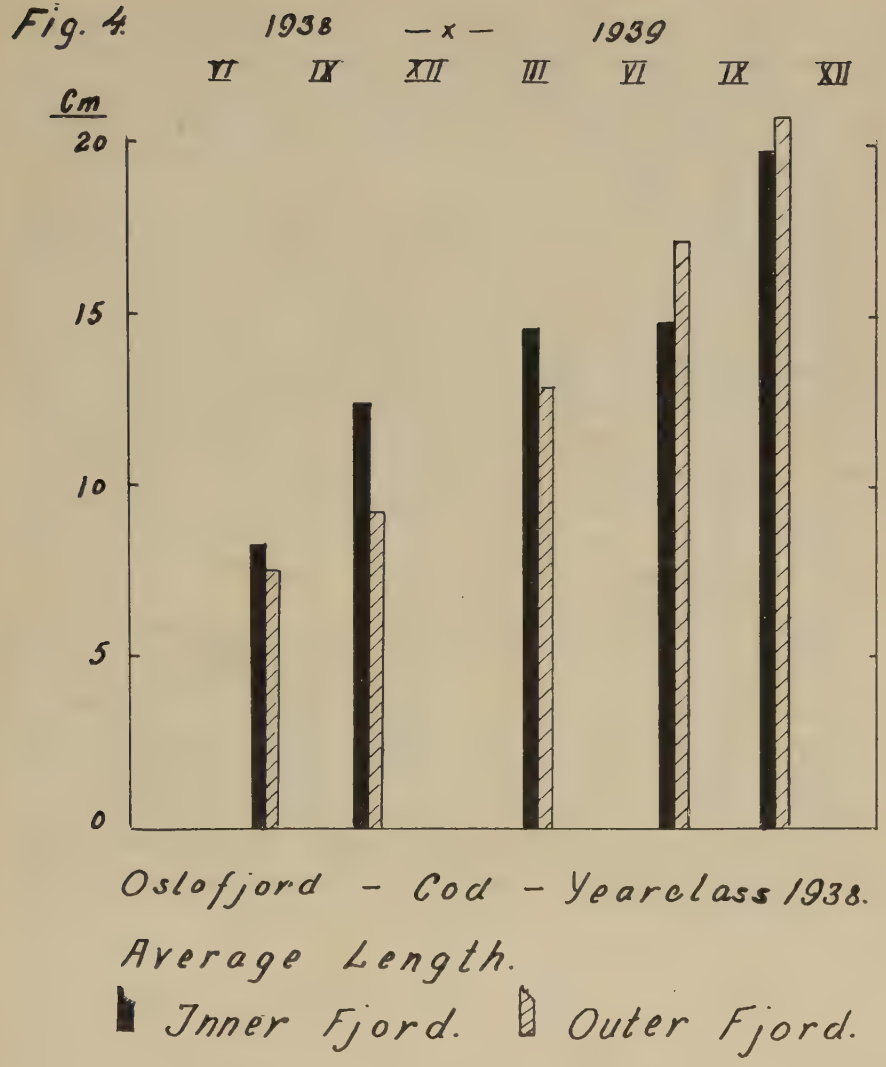


Fig. 3. The average sclerite measures of 10 cod of medium size autumn 1939.
Flödevigen.
Holmestrand.
Bonnefjorden.
2 4 6 8 10 12 14 16 18 20 22 24 26
L cm

strand (the outer part of the Oslofjord) are very much alike in having distinct minima. At Flødevigen the minimum occurs at a computed length of 8 to 15 cm, and at Holmestrand at 6 to 10 cm. In both areas the small sclerites are followed by numerous large sclerites, which decline in size towards the margin of the scale; the second zone with small sclerites is evidently about to form (see Plate I).

Turning to the material from the Bonnefjord, the inner part of the Oslofjord, the minima are often difficult to ascertain, and they occur with no regularity. The very large sclerites which were so conspicuous in the other areas, are entirely lacking.

In Fig. 3 are given the mean ordinates of the curves of Figs. 2 a, b and c. The main features of the individual curves are evident also



in the mean curves, in which the difference between the growth in the three localities is also illustrated.

At Flødevigen, near the open Skagerak, the cod attains a mean length of about 25 cm at 1½ years of age. The minimum sclerites in the first year are formed at a length of 10 to 12 cm, and are followed by very large sclerites in conformity with the quick growth. At Holmestrand the mean length of the fish is about 20 cm. Minimum sclerites are formed at a size of about 8 cm, and are followed by large sclerites. They are, however, fewer than at Flødevigen, the tendency to decreace is setting in earlier. In the Bonnefjord the mean size is about 18 cm.

The narrow sclerites occur when the fish is about 10 cm in length — and the very large sclerites are lacking. Inspection of the scales — or the graphs — from a great number of fish of the same yearclass shows that the figures given are in full conformity with the material — although as a whole the smaller individuals of course have more small sclerits and the larger more big sclerites.

The results obtained by measuring the scales referred to give a true picture of the mode of growth of the codling in these waters. Near the coast the cod grows quickly, in the outer Oslofjord less so. In the Bonnefjord the rate of growth of the 0-group is very high, but falls off greatly in later stages. This is illustrated in Fig. 4, taken from the material collected by Ragnv. Løversen (1946). This figure is based upon the measurements of some thousand cod of the 1938 yearclass. The same phenomenon has previously been described by Ruud (1939).

It is evident that the environmental factors influence the formation of sclerites in the scales of the young cod. The study of the central part of the scale of the grown up cod may thus inform us about the early history of the fish.

Owing to the war we were not able to follow the 1938 yearclass in the districts under consideration till the fish was full grown. The material collected from earlier yearclasses indicates, however, that we in the central part of the scales of the grown up fish from these waters find just the caracteristic features described above, indicating that the grown up cod has lived under similar conditions all its life.

The cod scale from the inner Oslofjord is always characteristic by the lack of well defined zones. This is also the case by the otoliths.

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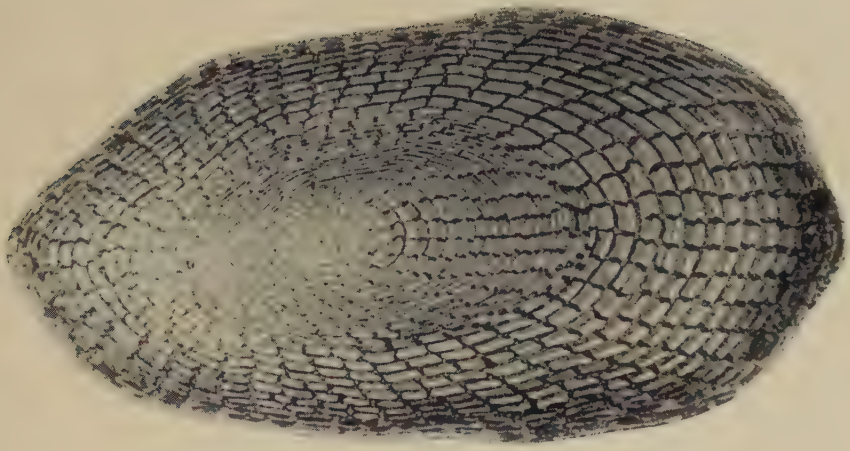
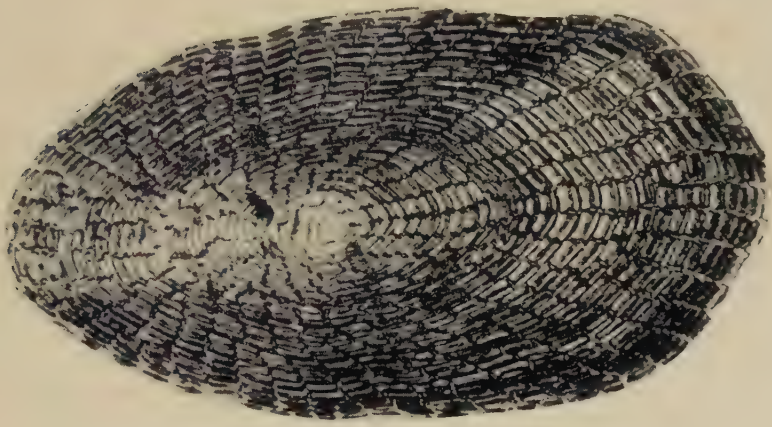
PLATE I. Foto: Ragnv. Løversen.



Flødevigen J.nr. 164/1939. September 19th. 25 cm.



Holmestrand J.nr. 1902/1939. October 3rd. 20 cm.

Bonnefjord J.nr. 1685/1939. October 7th. 18 cm.

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2) Skreiens alder, av Gunnar Rollefsen, p. 12.
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» 8. *Thor Iversen:* Some Observations on Cod in Northern Waters. 1934.
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